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Limb Correction of VIIRS and SEVIRI IR Channels for the Improved Interpretation of RGB Composites

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1. Red-Green-Blue (RGB) Composites

- **Combine information from several channels** into one composite image to address a specific forecast problem
- **Aid in real-time analysis** of atmospheric processes
- Created using EUMETSAT RGB recipes

2. Challenges with RGB Composites

A) Limb Effect (Limb Cooling)

- **Interferes with qualitative interpretation of RGB composites at large satellite viewing zenith angles (θ_Z)**
- Occurs as a result of an increasing the optical path length of the absorbing atmosphere as θ_Z increases
- **Causes anomalous cooling** of 5-10 K on the limb in water vapor and ozone channels; 1-5 K in window channels, depending on sensitivity to water vapor
- Uncorrected RGB composites from polar orbiting instruments, such as VIIRS, can only be reliably interpreted close to nadir
- Limits use of RGB composites from geostationary sensors at mid-latitudes
- To fully exploit the advantages of RGB products, it is necessary to correct the individual IR channels for limb effects prior to creating the composites

B) Cloud Effects

- Clouds lead to decrease in optical path length of absorbing atmosphere
- High clouds significantly decrease optical path length, so limb effect is minimal
- If imagery is corrected for limb effects without accounting for clouds, the correction will be inaccurate

C) Channel Differences between Sensors

- RGB products from multiple satellite sensors are often used jointly to provide more temporally continuous product and better track atmospheric features
- Each sensor has unique spectral response
- Makes comparison of similar products from multiple sensors difficult

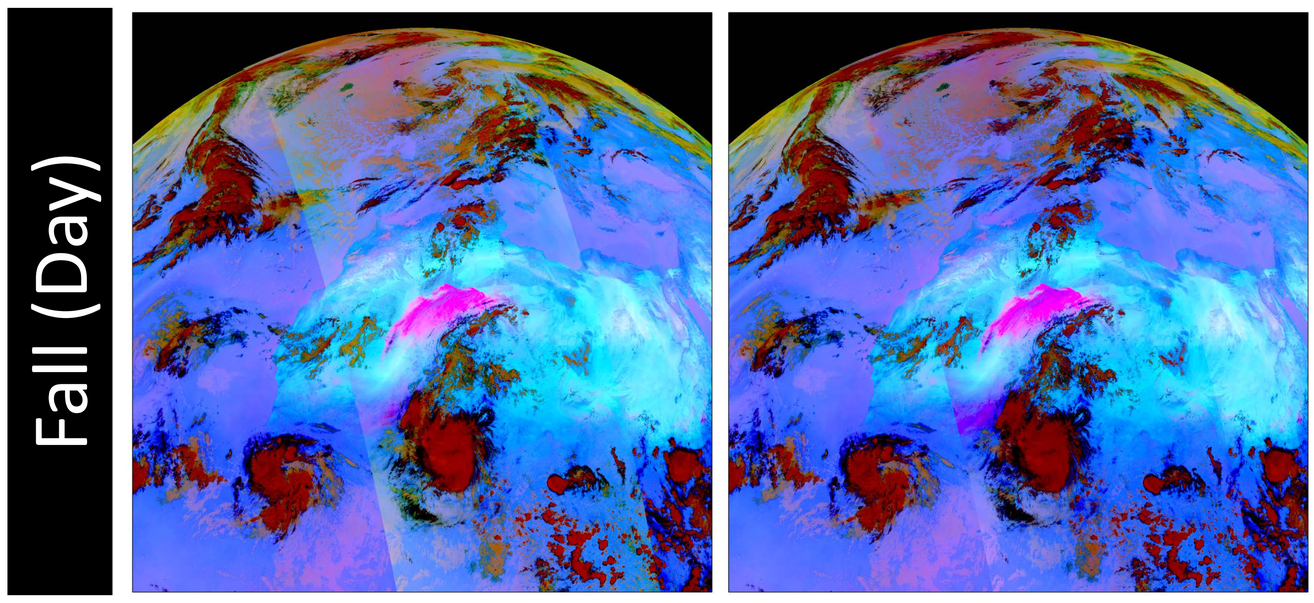


Figure 1. 3 September 2015 VIIRS Dust RGB (1243 UTC) uncorrected (left) and limb-corrected (right) merged with SEVIRI Dust RGB (1245 UTC)

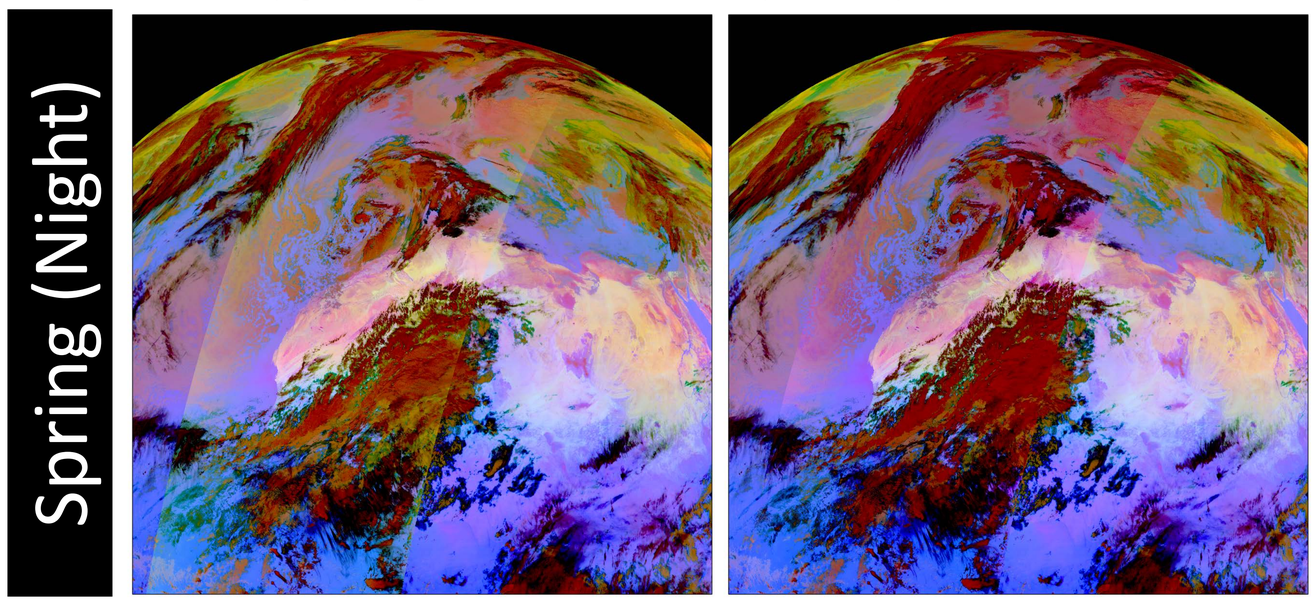


Figure 1. 19 March 2015 VIIRS Dust RGB (0235 UTC) uncorrected (left) and limb-corrected (right) merged with SEVIRI Dust RGB (0230 UTC)

Advantages of Limb-Corrected RGBs

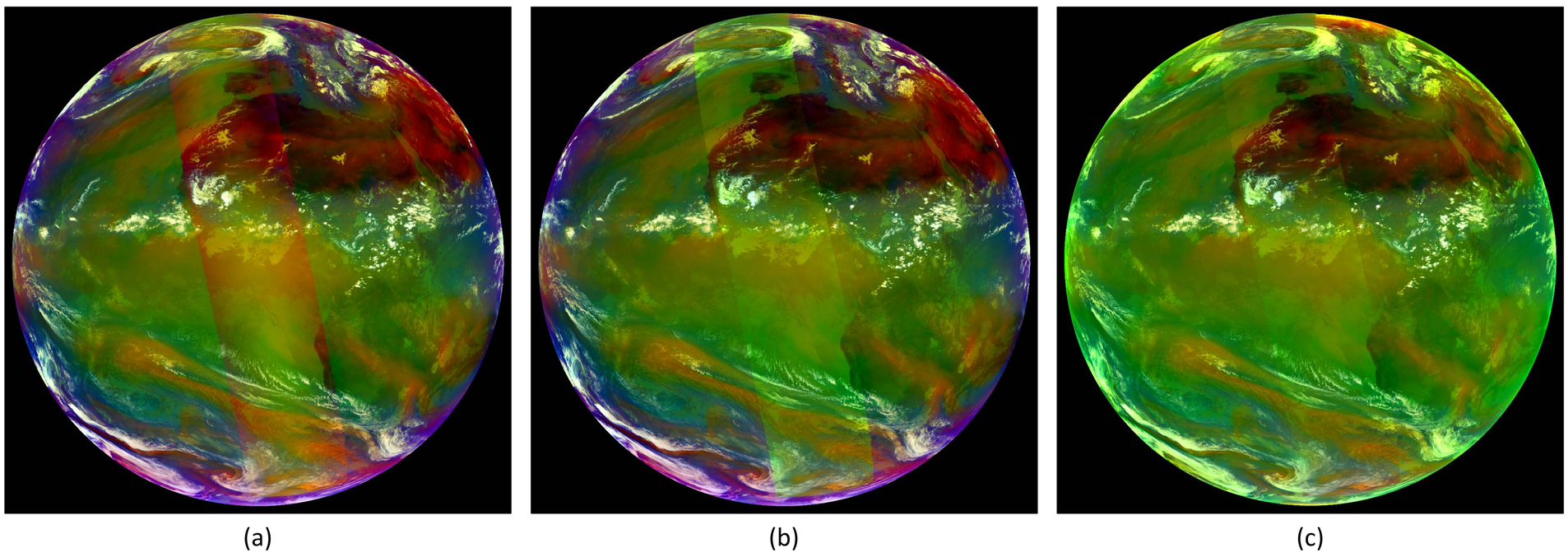
More accurate representation of atmosphere and surface on the limb

Ability to utilize the full satellite image, rather than just part of the image close to nadir

Improved transition between overlaid RGB composite images

Increased confidence in interpretation of RGB features

Improved forecaster situational awareness



(a) (b) (c)

Figure 3. 28 June 2015 Aqua MODIS Air Mass RGB (1320 UTC) merged with SEVIRI Air Mass RGB (1330 UTC) for (a) uncorrected MODIS and uncorrected SEVIRI, (b) limb-corrected MODIS and uncorrected SEVIRI, and (c) limb-corrected MODIS and limb-corrected SEVIRI.

3. Limb Correction

$$T_{Bcorr} = T_B - T_{offset} + C_2\, ln(cos\theta_Z)^2 - C_1\, ln(cos\theta_Z)$$

- T_{Bcorr} is the limb-corrected brightness temperature, T_B is the sensor measured brightness temperature, T_{offset} is the correction for channel differences between sensors, and θ_Z is the viewing zenith angle
- **Coefficients C2 and C1 (function of latitude and season)** derived from CRTM for each sensor IR channel using ECMWF profiles as input to model
- Valid for clear regions only. Ongoing work will address limb correction in cloudy regions
- **MODIS IR channels currently being limb-corrected at NASA SPoRT in real-time** and used to create RGB composites sent to end users
- For improved comparison, **nadir brightness temperatures for VIIRS and MODIS were adjusted to match the nadir brightness temperatures of SEVIRI**
- Differences in measured brightness temperature between sensors can be attributed to channel differences between sensors, since limb effect not a factor at nadir

4. Results

- **Removal of anomalous cooling** near swath edges
- **Very similar appearance of RGB products** between VIIRS and SEVIRI in clear regions
- Errors in cloudy regions, where cloud effects are not addressed and over deserts

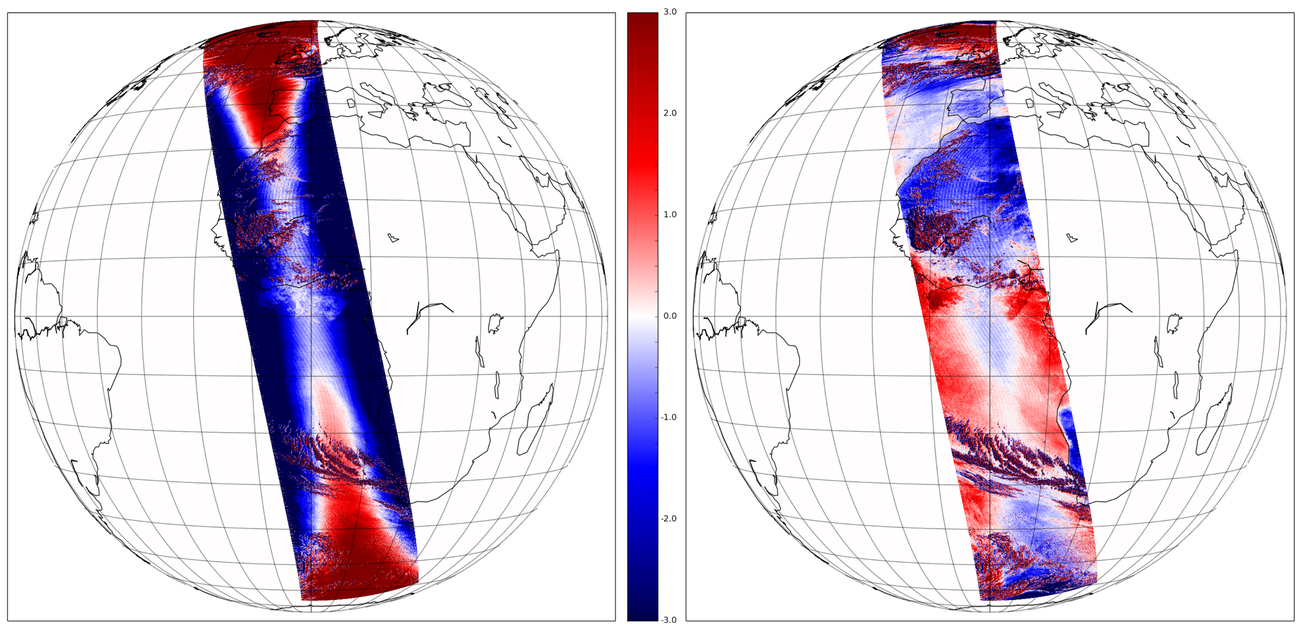


Figure 4. 28 June 2015 Aqua MODIS (1320 UTC) band 28 (7.33 µm) uncorrected (left) and limb-corrected (right) minus SEVIRI (1330 UTC) band 6 (7.35 µm) brightness temperature difference at common points. Note error in cloudy regions due to cloud effects and cloud motion.

5. Future Work

- Extend the limb and bias correction methodology to other geostationary sensors, including Himawari AHI and GOES-R ABI.
- Further investigate cloud effects to account for clouds in limb correction methodology

Direct questions to Kevin Fuell during conference

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